Sliding Mode Observer based Backstepping Control for Generator Excitation Systems

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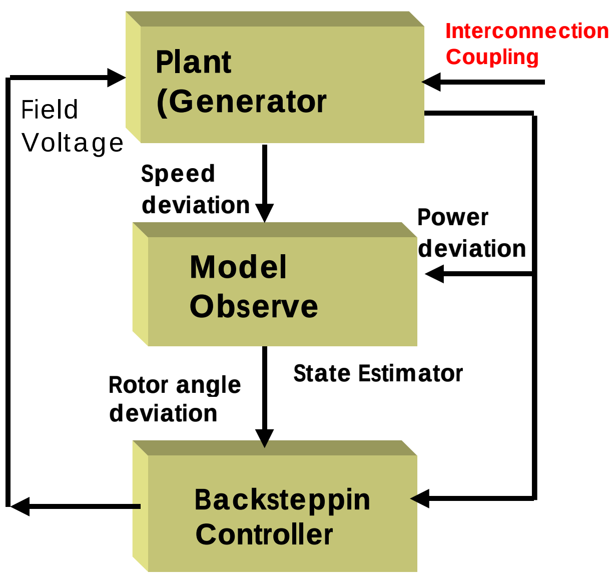
Research at West Virginia University's Advanced Power and Electricity Center (APERC) is investigating new concepts for controlling the electric voltage of the public's grid synchronous generators. A novel method is presented based on a combination of nonlinear sliding mode observers and backstepping control design to enhance generator excitation controls. The proposed method employs Particle Swarm Optimization Technique (PSO) to search for the optimal setting of the controller and observer parameters in order to improve transient stability. The excitation control systems are required to damp system oscillations that may affect stability after severe contingencies occurred.

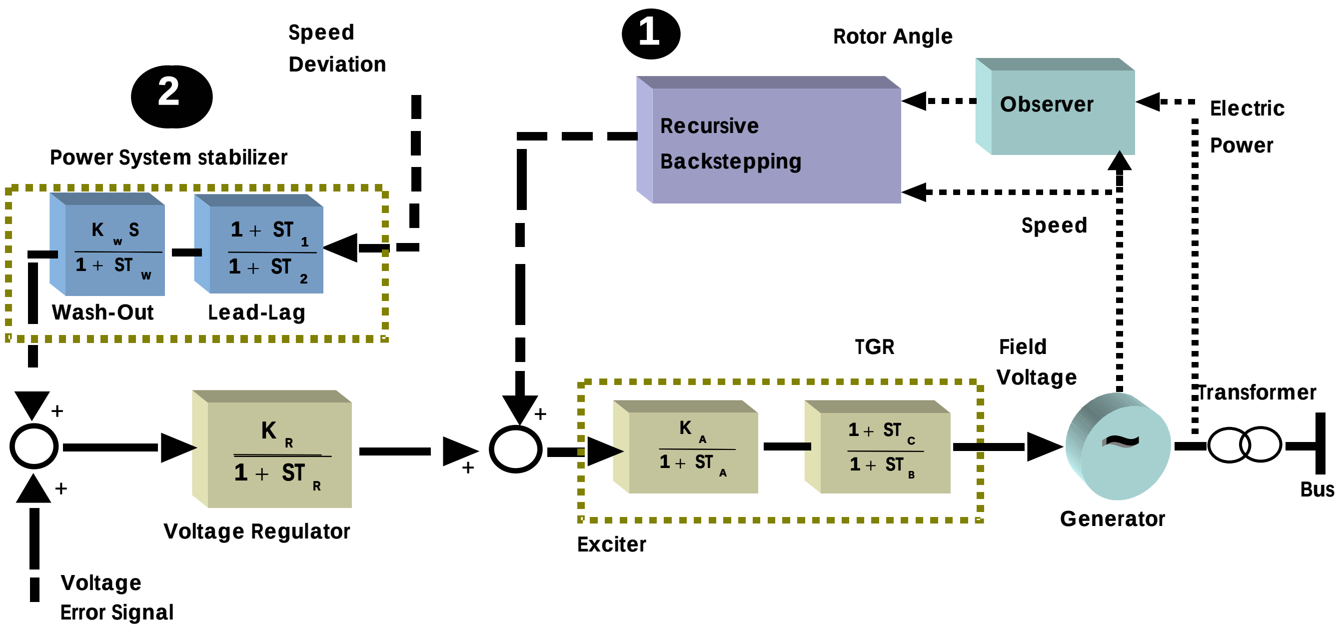
Exact measurements often play a critical role in control performance. However, exhaustive installation of measurement equipment, especially in large-scale system such as the public electric power grid, is impossible. Instead, observers are used to provide estimates. Sliding mode observers provide a framework for a general class of nonlinear systems. Their application provides a systematic approach for observing nonlinear power systems subject to bounded disturbances due to power flows through interconnecting tie lines.



Overview of the Observer and Backstepping Controller for improved generator excitation control.

The backstepping controller approach casts the model of generators into a parametric form that allows a cascaded subsystem design. Each subsystem is stabilized by a state feedback control law obtained for the scalar case and based on a candidate Lyapunov function to achieve asymptotic stability at the origin. Adding one subsystem at a time, the final state feedback controller is obtained. Consequently, the design procedure of both feedback controller and related Lyapunov function becomes a systematic process. The resulting combination of observer and controls are tuned by a particle swarm optimization procedure to enhance steady-state and transient stability characteristics.

Simulation results for a multi-machine power system show the effectiveness of the proposed controls and the tuning process. The performance of the controls is favorable when compared with conventional and existing damping control schemes as Power System Stabilizer (PSS) technique.



Proposed observer based backstepping excitation control (1) and conventional linear controls (2).

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